### 4.4.5 Asset management system documentation

The organization shall establish, implement and maintain up-to-date documentation to ensure that its asset management system can be adequately understood, communicated and operated. The asset management system documentation shall include:

a) a description of the main elements of the asset management system and their interaction, and direction to related documents;

b) the asset management policy, strategy, and objectives;

c) documents, including records, required by **Clause 4** of this specification.

The organization shall establish documented procedure(s) and/or operating criteria if their absence could lead to failure to achieve its asset management policy, asset management strategy, asset management objectives or to control identified asset management risks.

***NOTE 1*** *The asset management policy, strategy and other elements of the asset management system do not have to be produced as separate documents.*

***NOTE 2*** *It is important that documentation is proportional to the level of complexity and risks being managed. It should also be appropriate to the level at which the documentation will be used and kept to the minimum required for effectiveness and efficiency.*

Organizations seeking to implement the requirements of PAS 55-1 on asset management system documentation, should consider the recommendations and guidance provided below.

a) Documentation enables communication of intent and consistency of action. The organization should have sufficient up-to-date documentation in place to ensure that its asset management system can be adequately understood and effectively and efficiently worked to. It is not a requirement to put in place specific documents for asset management, provided that existing documentation and processes meet the requirements of PAS 55-1. As a general rule, documentation should only be created when it adds value.

   The extent of the asset management system documentation can differ from one organization to another due to:

   - the size of the organization and the type of activities;
   - the complexity of processes and their interactions;
   - the competence of personnel;
   - the extent to which it is necessary to demonstrate fulfilment of the asset management system requirements.

b) The organization should review its documentation needs before developing any new documentation to control its asset management activities. In practice, organizations often have in place documentation at operational levels within functions or departments, but the co-ordination and alignment of activities may not be well controlled, particularly where these documents have originated in different business streams or even different organizations. Furthermore, a limited number of new documents are sometimes required to manage the continuous improvement and co-ordination of the asset management system with the operational procedures.

c) There is no requirement to develop documentation in a particular format in order to conform to PAS 55-1. There is no requirement to create a discrete asset management manual to describe the scope of the asset management system, its main elements and their interaction. The organization should decide what form best meets its business needs. For many organizations a separate asset management policy and asset management strategy, together with a document describing the scope, key accountabilities and operational documentation of the asset management system, provide value and improve organizational alignment. This approach can be particularly convenient and effective if an organization already has an established management system in place, in order to describe the interrelationships between the existing system and the requirements of PAS 55-1.

d) There are relatively few elements of the asset management system for which PAS 55-1 specifically requires explicit documentary evidence. These include:

   - an asset management policy;
   - an asset management strategy;
   - asset management plan(s);
   - roles, responsibilities and authorities;
   - how outsourced parts of management system will be controlled and integrated into the organizations' asset management system (see **4.4.2**);
   - records (see **4.6.6**).

e) PAS 55-1 requires an organization to establish and maintain further documentation if its absence could lead to failure to:

- achieve its asset management policy, asset management strategy, asset management objectives;
- control identified asset management risks;
- efficiently and cost effectively implement its asset management plan(s).

In other words, the degree of documentation should consider the potential need and usage – it is not sufficient to adopt a policy of standardization whereby the same level of detail is applied in all circumstances. The organization should consider "what if?" in determining the level of documentary coverage that is appropriate in each area or activity.

f) Each organization should determine the extent of documentation required and the media to be used. In addition to those identified in d) above, PAS 55-1 makes reference to a limited number of types of documentation which can be used within an asset management system. These include functional policies, strategies, procedures, standards and operating criteria. Organizations may also utilize types of documentation such as technical specifications, technical instructions, work instructions or guidance notes to control asset management activities.

g) Asset management functional policies, supporting the overall asset management policy, provide a framework for the control of a specific asset management related activities (such as capital investment, purchasing, operations, customer service, maintenance, contracting, safety and environmental management – see **4.4.5 i)**. Functional policies are normally mandatory within an organization, and can be described using different names in different contexts. It is essential that such documents comply with policies adopted by the organization which define at high level the organization's principles and requirements (these include the asset management policy). Functional policies should also be consistent and guided by the asset management strategy where they relate to the management of activities within the asset management system.

h) Functional policies provide the workforce with clarity for what is expected of them and the boundaries for any permissible deviance. They assist managers to implement stated asset management objectives and plans, and they should also constrain them within carefully defined boundaries. When formulating functional policies, care should be taken not to conflict with other such policies or restrict managers to the extent that they are unable to take appropriate action for the optimal life cycle management of the assets. Similarly, the functional policies should be appropriate to the criticality and value of the assets and activities to which they apply.

i) Organizations can have a number of asset management functional policies, functional strategies and functional plans. Typically these can include:

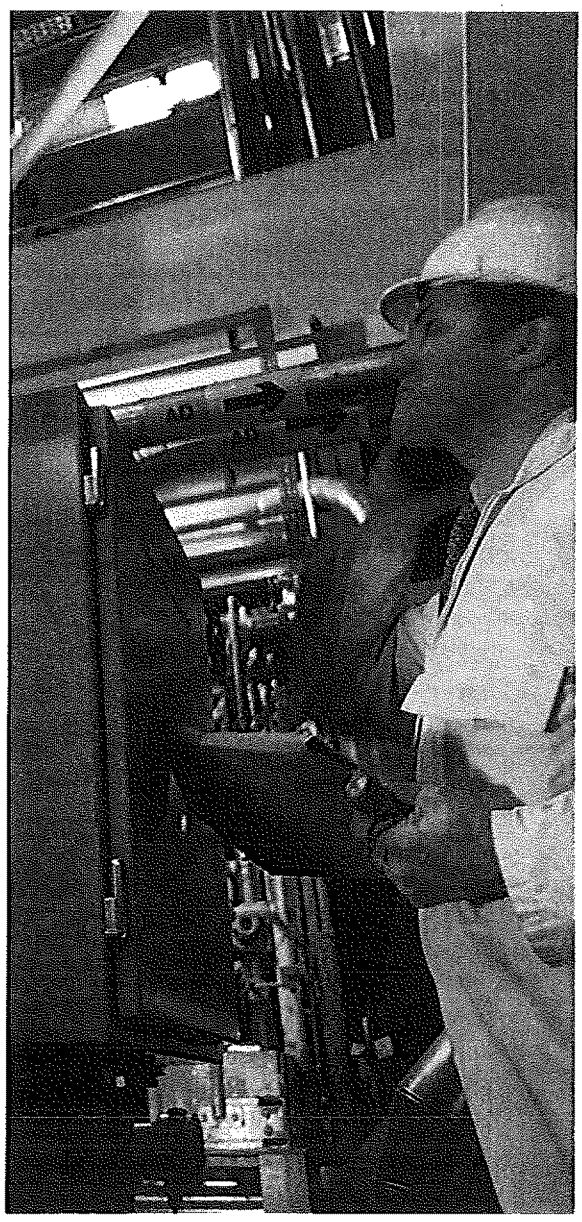
- asset accounting and activity costing;
- maintenance, inspection, condition and performance monitoring;
- asset operation or utilization;
- planning and budgeting;
- capital investment and life cycle costing;
- contingency planning and emergencies;
- data, information and knowledge management;
- demand management and customer expectation policy;
- energy efficiency and environmental aspects, e.g. renewable resources, recycling, waste management, air purity, hygiene;
- human resources, skills development and competencies;
- innovation and change management;
- asset modifications, replacement, disposal, recycling;
- risk assessment and management;
- safety, health and environmental management;
- spares, materials and purchasing;
- contractor and supplier management;
- interfacing with regulatory bodies.

j) Based on the documentation criterion in e) above, one of the more significant documentation requirements can be for an organization to establish documented procedures. The term "procedure" is often used in management system standards and there can be confusion as to what a procedure is and how it relates to a process. In simple terms, a process is an activity, and a procedure is the formalization of the process, stating how the process should be performed (see PAS 99). A procedure may be documented, but does not have to be (see PAS 55-1, **3.27**).

k) It is for an organization to determine whether it needs to document a procedure in order to provide assurance as described in e) above. Examples of documented procedures which an organization decides it needs to establish to control its asset

management activities may include procedures for:

- design, procurement, construction, installation and commissioning of new equipment;
- review, approval and control of contracts;
- operation of plant and equipment;
- repair, maintenance and inspection activities;
- calibration and maintenance of tools and test equipments;
- renewal, refurbishment, modification and disposal of equipment;
- management of spares.



**4.4.6 Information management**

The organization shall identify the asset management information it requires to meet the requirements of **Clause 4** of this specification considering all phases of the asset life cycle. The information shall be of a quality appropriate to the asset management decisions and activities it supports.

The organization shall design, implement and maintain a system(s) for managing asset management information. Employees and other stakeholders, including contracted service providers, shall have access to the information relevant to their asset management activities or responsibilities. Where separate asset management information systems exist, the organization shall ensure that the information provided by these systems is consistent.

The organization shall establish, implement and maintain procedure(s) for controlling all information required by **Clause 4** of this specification. These procedures shall ensure:

a) the adequacy of the information is approved by authorized personnel prior to use;

b) information is maintained and adequacy assured through periodic review and revision, including version control where appropriate;

c) allocation of appropriate roles, responsibilities and authorities regarding the origination, generation, capture, maintenance, assurance, transmission, rights of access, retention, archiving and disposal of items of information;

d) obsolete information is promptly removed from all points of issue and points of use, or otherwise assured against unintended use;

e) archival information retained for legal or knowledge preservation purposes is identified;

f) information is secure and, if in electronic form, is backed up and can be recovered.

Good asset management requires meaningful, quality, timely asset and asset management information. Asset management information is essential for achieving an effective and efficient asset management system and for the continual improvement of that system. Asset management information includes asset registers, drawings, contracts, licences, legal, regulatory and statutory documents, policies, standards, guidance notes, technical instructions, procedures, operating criteria, asset performance and condition data, tacit

knowledge and all types of asset management records. Further information on documentation is identified in **4.4.5** and records in **4.6.6.**

*Organizations seeking to implement the requirements* of PAS 55-1 on information management, should consider the following recommendations and guidance:

a) Organizations should identify the information essential to meeting the requirements of PAS 55-1. An organization should consider the level of accuracy and completeness for different information items that are necessary to support the delivery of its asset management strategy, objectives and plan. Asset management information should be capable of enabling an organization to:
   - optimize its asset management strategy and optimize/prioritize its asset management plan(s);
   - assess the financial benefits of planned improvement activities;
   - determine the operational and financial impact of asset unavailability or failure;
   - *make life cycle cost comparisons of alternative* capital investments;
   - identify expiry of warranty period and warranty;
   - determine the end of economic life of assets/asset systems, e.g. the point in time when the asset related expenditure exceeds the associated income;
   - determine the cost of specific activities (activity based costing), e.g. the total cost of maintaining *a specific asset(s)/asset system;*
   - obtain/calculate asset replacement values;
   - undertake financial analysis of planned income and expenditure;
   - obtain/calculate the financial and resource impact of deviating from plans that might result in a change in asset availability or performance (e.g. what is the financial impact of deferring the maintenance of a specific generator by six months);
   - assess its overall financial performance;
   - undertake the ongoing identification, assessment and control of asset related risks;
   - comply with statutory and regulatory obligations.

b) Asset information should normally be assigned at the lowest component level of an asset or asset system that requires discrete replacement or maintenance actions. For example, if the organization's maintenance strategy were always to run a particular pump to failure and then replace it, there would be little point in recording information (and procedures) for replacing the component pump seal. The normal level of detail required, therefore, is at the maintainable unit level (sometimes this is *referred to as a "Maintenance-Significant Item").* However, information attributed at a lower component detail may be worthwhile for the identification of failure modes and the diagnosis of failure root causes.

   The organization should compare the cost of establishing, collecting and maintaining asset information with the value derived from analysing and using it, i.e. its criticality to business decisions and granularity, precision or level of detail that is needed. Failure adequately to consider these compromises can result in poorly and inconsistently populated information systems and degraded information quality. This degraded quality can damage the credibility of the information provided and it can also lead to unnecessary costs being incurred.

   In establishing its asset information management system(s), the organization should consider the identification and definition of items of information that will be managed during the asset life cycle, and for a defined period beyond the disposal of assets, in accordance with the organization's requirements including legal, regulatory, statutory and other asset management requirements that are applicable to it. Examples of information to be considered include the following:
   - descriptions of assets, their functions and the asset system they serve;
   - unique asset identification numbers;
   - locations of the assets, possibly using spatial referencing or geographical information systems;
   - the criticality of assets to the organization;
   - details of ownership and maintenance demarcation where assets interface across a system or network of assets;
   - engineering data, design parameters, and engineering drawings;
   - details of asset dependencies and interdependencies;
   - vendor data (details of the organization that supplied the asset);
   - commissioning dates and data;
   - the condition and duty of assets;
   - condition and performance targets or standards;
   - key performance indicators;
   - asset related standards, process(es) and procedure(s);

- access planning and work schedules;
- details of the tasks to be carried out;
- work instructions together with diagrams and reporting requirements, legal obligations and safety/environmental considerations;
- task risk assessments and control measures;
- criteria of non-conformance and the actions to be taken;
- when assets were last maintained/inspected and when these tasks are next due;
- list of overdue/outstanding tasks;
- historical record of planned and unplanned maintenance tasks performed,
- details of historical asset failures, causes and consequences (if known);
- operational data including performance characteristics and design limits;
- details of emergency plans including responsibilities and contact details;
- identities and levels of spares held, interchangeability, specifications and storage locations;
- financial data including, where available, cost of historical and planned maintenance tasks, operating costs, downtime impact, current asset replacement value, original purchase cost;
- asset related contractual information.

Systems for managing asset information can use a range and combination of media and technologies. The systems should enable an organization to identify, collect, retain, transform and disseminate its asset management information. These systems can range from straightforward paper based systems to sophisticated electronic solutions. It is for an organization to decide which types of systems best meet its needs for particular applications. The more sophisticated examples can integrate many of the following components:

- asset registers;
- document management systems;
- work/programme planning and scheduling systems;
- materials management systems;
- spares inventory systems;
- purchasing systems;
- decision-support systems, e.g. maintenance optimization, capital expenditure planning, whole life costing models, etc;
- asset utilization systems;
- performance reporting systems;
- geographical information systems (GIS) and spatial analysis toolkits (for the analysis of GIS data);
- asset possession/shutdown/outage planning systems;
- SCADA (Supervisory Control and Data Acquisition Systems);
- condition monitoring systems;
- automation systems;
- knowledge management systems;
- staff location, scheduling and despatch systems.

c) It is not necessary for an organization to establish a complete asset management information system in-house. Component parts or systems forming the whole asset management system may be supplied by others. However, it is essential that all component systems, irrespective of source, are compatible with the whole system and that the information provided by these component systems is consistent and contains suitable cross references to allow cross system analysis.

d) The systems for managing asset management information should be designed so that data and information is readily accessible and available to all relevant personnel under routine and non-routine conditions, including emergencies. For example, this should ensure that up-to-date plant engineering drawings, hazardous material data sheets, procedures and instructions are available to process operators, and all who can require them in an emergency.

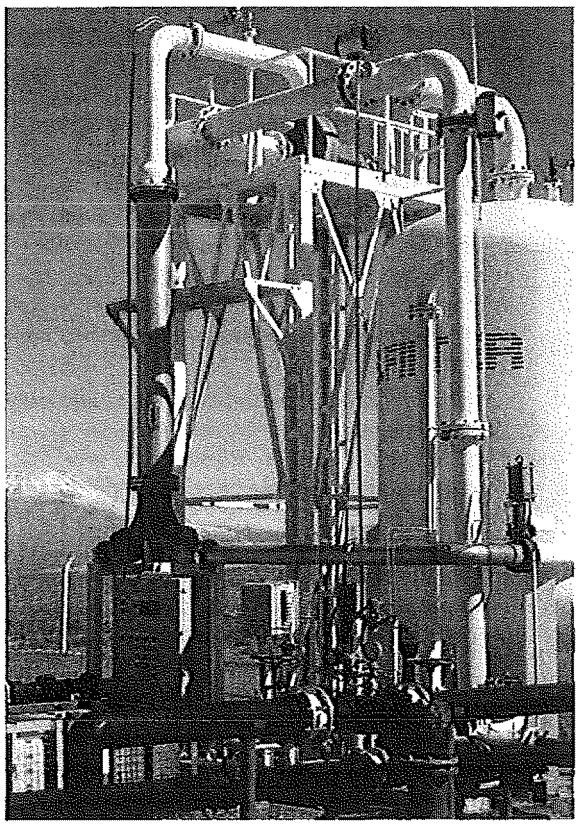
All information, including documentation, required for the operation of the asset management system and the performance of the organization's asset management activities should be controlled. To achieve this, an organization should establish, and where appropriate document, arrangements and/or processes to address the:

- allocation of roles, responsibilities and authorities for the origination, generation, capture, maintenance, retention, transmission, access to, assurance, archiving and disposal of items of information;
- definition of the content, meaning, formats and medium for the representation, retention, transmission and retrieval for each information item;
- requirements for information maintenance, including version control and assurance activities;
- requirements for the generation, capture or importing of the identified items of information;
- requirements for the storage of information items

according to integrity, security and confidentiality requirements;

- retrieval and distribution of information to designated parties as required by agreed schedules or defined circumstances;
- requirements for the archival of designated information, for example for the purpose of retaining audit records and knowledge preservation;
- requirements for the disposal of obsolete, unreliable or unwanted information in accordance with the organization's requirements and security and privacy requirements;

e) The organization should also establish, implement and maintain a process(es) and/or a procedure(s) for the retention, management and disposal of records. Records should be stored in a safe place, readily retrievable and protected from deterioration. Critical asset management records should be protected from possible fire and other damage or loss as appropriate, or as required by law. Consideration should also be given to issues surrounding the holding and use of electronic records, e.g. legal constraints, storage media obsolescence, access controls.



### 4.4.7 Risk management

#### *4.4.7.1 Risk management process(es)*

> The organization shall establish, implement and maintain documented process(es) and/or procedure(s) for the ongoing identification and assessment of asset-related and asset management-related risks, and the identification and implementation of necessary control measures throughout the life cycles of the assets.

Risk management is an important foundation for proactive asset management. Its overall purpose is to understand the cause, effect and likelihood of adverse events occurring, to optimally manage such risks to an acceptable level, and to provide an audit trail for the management of risks. This is achieved by:

- identifying potential risks associated with the assets, and making an estimate of the associated risk levels, on the basis of existing or proposed risk controls;
- determining whether these risks are tolerable;
- determining whether further analysis is required to establish whether the risks are, or are not, tolerable;
- devising risk controls where these are found to be necessary or desirable.

Risk management is integral to all asset management processes. However, there is specific need to have processes in place to identify and monitor risks, linked to control mechanisms for controlling, mitigating or recording them. It is a legal requirement that safety of employees, third parties and the public is managed to the appropriate legislative standard (and there may be specific industry sector regulations). There are further compliance requirements to manage environmental risks, and to comply with the legislation on corporate and financial risk management.

PAS 55-1 recognizes the need to integrate the management of risk throughout the asset management system, beyond the requirements of legislation in order to prioritize and optimize activities based on cost, risk and performance. In practice, this extends to the management of business risk and includes long-term sustainability.

#### *4.4.7.2 Risk management methodology*

The organization's methodology for risk management shall:

a) be proportionate to the level of risk under consideration;

b) be defined with respect to its scope, nature and timing to ensure it is proactive rather than reactive;

c) include, where appropriate, the assessment of how risks change or can change over time and usage;

d) provide for the classification of risks and identification of those risks that are to be avoided, eliminated or controlled by asset management objectives and plans (see **4.3.2** and **4.3.3**);

e) be consistent with the organization's operating experience and the capabilities of risk control measures employed;

f) provide for the monitoring of required actions to ensure both the effectiveness and the timeliness of their implementation (see **4.6.1**).

#### *4.4.7.3 Process steps*

The methodology requirements of PAS 55-1 can be met largely by ensuring that a step by step, systematic approach is adopted to the management of asset risks:

- *classify assets and define scope*: prepare a list of asset systems and their constituent assets, and gather information about them, including the management and control activities which affect the assets' performance; define the scope and limits of the individual asset risk assessments;
- *identify credible risks*: create a table of potential events and their causes;
- *identify the risk controls* that exist (or are proposed for planned assets and planned activities);
- *determine level of risk*: estimate the likelihood and consequences for each potential event, assuming that planned or existing controls are in place. The effectiveness of any existing risk controls, and the likelihood and consequences of their failure, should also be considered;
- *determine the tolerability of the risks*: decide whether planned or existing controls (if any) are sufficient to keep the risks under control and to meet any legal, statutory and other asset management requirements.

These principles should be in place and integrated into all activities and procedures throughout the asset management system, together with the necessary governance and assurance to ensure that risk controls are effectively implemented and monitored.

It is an important principle embedded in PAS 55-1 that a whole life cycle approach is adopted. Therefore, risk management of physical assets should include consideration of risks across the whole asset life cycle. For example, the design process should include the identification and management of risks throughout the life of the asset, taking account of the operating conditions and criticality of the asset utilization.

When determining risk controls, or considering changes to existing controls, consideration should be given to reducing the risks according to the following hierarchy:

1) elimination;
2) substitution;
3) physical controls;
4) signage/warnings and/or administrative/procedural controls.

#### *4.4.7.4 Risk registers*

Risk registers are a common and effective mechanism for recording and managing risks within the organization. At a corporate level this may comprise a list of significant risks defined in terms of likelihood and consequence, together with existing mitigation, planned actions and responsibilities. These should include significant asset related risks. The type of risk should also be recorded to enable clear classification and auditability of safety and other types of risk. The monitoring and management of this risk register includes senior management review, together with clear processes and accountabilities for supporting processing and delivery of planned mitigation (for further detail on managing risk for corporate governance see PD 6668:2000). The process of maintaining, updating and auditing the risk register is one of the key asset management processes, and should be referenced in the asset management strategy. In order to ensure that appropriate priority is placed on risks of different types, a common assessment methodology should be adopted, enabling risks of a different nature to be considered and managed.

#### *4.4.7.5 Management of asset-related risks*

The management of asset risks should be carried out using processes that are consistent with any corporate risk register, enabling asset related risks to be escalated to the corporate risk register where they are of sufficient magnitude. Asset-related risks need to be

identified and recorded in a way that is appropriate to the type of asset or asset system, taking into account their utilization and variety of failure consequences.

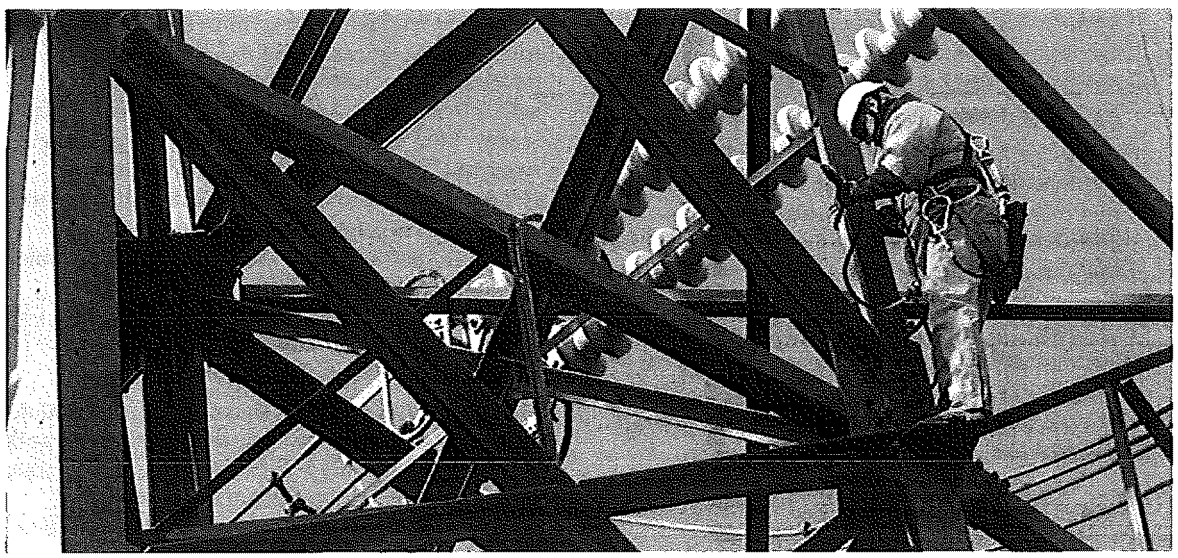
It is theoretically possible to provide a risk evaluation for every asset and asset system owned by an organization. This is not often a practicable solution, and it is more usual practice to focus primarily on significant risks, with lesser degrees of reporting and control required for lower risk areas. Many small, similar risks, however, can combine to represent significant systemic concerns, so it is necessary for the organization to be able to consider similar risks from across the systems so that the overall impact on the business can be evaluated, and the most appropriate organization-wide controls can be put into place, e.g. programmes of work or common procedures.

The nature of asset-related risks is that they are also likely to vary in time, as a result of many factors including the degradation of assets. Good risk management systems for asset management include recognition of how risks change with time (for example, with age or use), and the control of such changing risks is critical to asset maintenance and renewal decisions. However, the optimization of such decisions is complex and should be undertaken with particular care (for example, taking account of the degree to which the planned activity "resets the clock" of deterioration processes, considering any risks introduced by the planned activity, and calculating the optimal interval for periodic tasks, or renewal timing).

*4.4.7.6 Asset criticality*

The concept of asset criticality is a particular manifestation of risk management – this is the recognition that assets and asset systems have differing importance (value), or represent different vulnerabilities, to the organization. Criticality will usually include, but is not limited to, the risks of asset failure or non-performance. Criticality may also consider asset capital value, performance or efficiency, flexibility and other characteristics that reflect organizational goals and values. The corresponding asset characteristics should be assessed and weighted or scaled in a consistent manner to determine asset criticality for the purposes of prioritized asset management attention. Some assets of low material value, or indirect business contribution, may still have the potential to cause high impact in the event of failure (for example, safety relief valves).

Care should be taken in the definition and determination of asset criticality that includes risk elements. Some organizations refer to criticality only in terms of the potential failure consequences of the assets or asset systems; this may be suitable for prioritizing repairs or corrective actions for failures that have already occurred, but the true risks (probabilities multiplied by consequences) should normally be used within asset criticalities for the purposes of planning asset management (and risk management) actions. In some cases, where risks represent very low probability, very high consequence events (such as major safety risks), a degree of "disproportionality" should be considered to artificially increase the criticality, in recognition of the greater uncertainties associated with such risk estimations.



*4.4.7.7 Risk identification and assessment*

The identification and assessment of risks shall consider the probability of credible events and their consequences, and shall as a minimum cover:

a) physical failure risks, such as functional failure, incidental damage, malicious damage or terrorist action;

b) operational risks, including the control of the asset, human factors and all other activities which affect its performance, condition or safety;

c) natural environmental events (storm, floods, etc., including the likely effects of climate change);

d) factors outside of the organization's control, such as failures in externally supplied materials and services;

e) stakeholder risks, such as failure to meet regulatory performance requirements or risks to the reputation of the organization;

f) risks associated with the different life cycle phases of assets (see **4.5**).

Risk is defined as the product of probability and consequence (for risk terminology see PD ISO/IEC Guide 73). Risk identification and assessment needs to recognize and include consideration of both these factors. The complexity of modelling and risk controls should be commensurate with the nature and magnitude of the risks being managed. It is important that risk assessment is applied coherently and consistently throughout the organization. Ideally, risk assessment should be based on a common approach and methodology with a common calibrated scale for quantification, but if this is not practicable, then care should be taken that the way risk is treated for different types or scales of risk is compatible.

Techniques for identifying, quantifying and managing asset-related risks, with varying levels of complexity, exist in different business sectors. Some of these are identified below and references to more general methods and techniques are provided in the AIRMIC, ALARM, IRM.

*Risk identification:*

- SWOT analysis (Strengths, Weaknesses, Opportunities, Threats);
- BPEST analysis (Business, Political, Economic, Social, Technological);
- PESTLE (Political, Economic, Social, Technical, Legal, Environmental);
- HAZOP (Hazard and Operability Studies);
- Risk assessment workshops;
- Industry benchmarking;
- Incident investigation;
- Auditing and inspection.

*Risk analysis*

- Threat analysis;
- Failure Mode and Effect Analysis (FMEA);
- Failure Mode and Effect Criticality Analysis (FMECA);
- Root Cause Analysis (RCA);
- Event Tree Analysis (ETA);
- Fault Tree Analysis (FTA);
- Deterioration, dependency or system performance modelling.

*Selection of controls*

- Reliability Centred Maintenance (RCM);
- Risk Based Inspection (RBI);
- Instrument Protective Function (IPF).

These are not exhaustive lists, and organizations should consider adopting combinations of techniques as appropriate to the asset criticalities and diversity of risk types. In addition to these general methods and techniques, there are a variety of decision support tools and proprietary database products which can be employed to support risk assessment, auditing and ongoing management. In particular, there are a number of reliability- and risk-based methodologies for determining appropriate inspection and maintenance strategies, and cost/risk optimization of such strategies.

Organizations should consider their individual requirements, including the nature and scale of their business, the availability of information and implementation practicalities, when adopting appropriate methods and techniques. Some techniques require significant training and ongoing commitment of resources to be implemented effectively.

*4.4.7.8 Use and maintenance of asset risk information*

The organization shall ensure that the results of risk assessments and the effects of risk control measures are considered and, as appropriate, provide input into:

a) the asset management strategy;

b) the asset management objectives;

c) the asset management plan(s);

d) the identification of adequate resources including staffing levels;

e) the identification of training and competency needs (see **4.4.3**);

f) the determination of controls for assets' life cycle activities, and the implementation of asset management plan(s) (see **4.5**);

g) the organization's overall risk management framework.

The organization shall keep the results of identification of risks, risk assessments and determined controls up-to-date, and document these where not doing so could affect the delivery of the asset management objectives and the asset management strategy.

In order to manage risks effectively, the consideration of risk should be embedded into all activities and procedures throughout the asset management system and preferably asset related risks should be addressed as part of the organization's corporate risk management framework.

Risks should be identified and managed as part of all asset management activities considering risks throughout the life cycle of assets. For example, the design process should include the identification of risks during the operation and maintenance phase of the asset, including its eventual decommissioning and disposal and taking account of the operating conditions and criticality of the asset.

**4.4.8 Legal and other requirements**

The organization shall establish, implement and maintain process(es) and/or procedure(s) for identifying and accessing the legal, regulatory, statutory and other applicable asset management requirements.

The organization shall ensure that the applicable legal and other external obligations or requirements are identified and incorporated into the corresponding elements of its asset management system.

The organization shall keep this information up-to-date. The organization shall communicate information on legal and other requirements to all relevant stakeholders.

Organizations seeking to implement the requirements of PAS 55-1 on compliance with legal and other requirements, should consider the following recommendations and guidance:

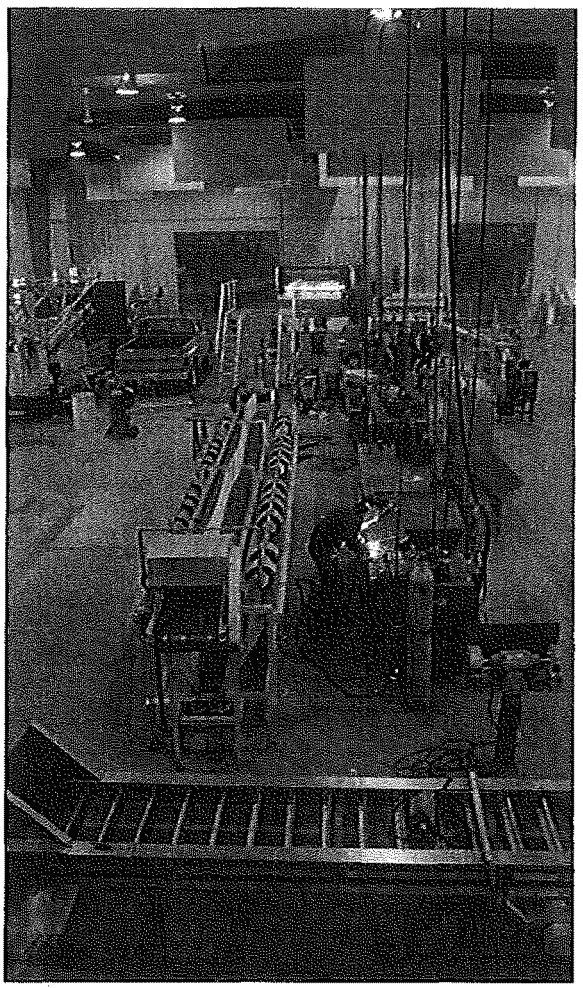
a) The organization should be aware of, and understand, how its activities are, or will be, affected by applicable legal and other requirements, and communicate this information to relevant personnel.

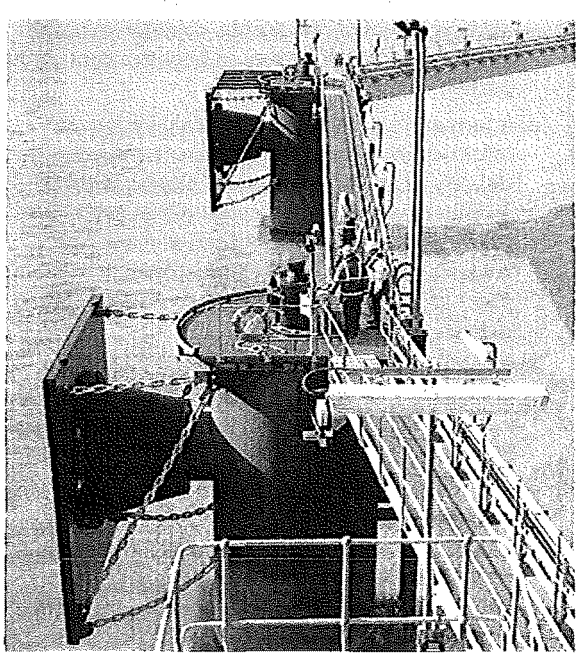
   ***NOTE*** *The requirement of* ***4.4.8*** *of PAS 55-1 is intended to promote awareness and understanding of legal responsibilities. It is not intended to impose an obligation on the organization to establish libraries of legal or other documents that are rarely referenced or used.*

b) The organization should operate a system through which it can identify the legislation, statutes and regulations applicable to its activities, and through which it can monitor forthcoming changes in such legislation. This should include arrangements to disseminate this information to affected parties and ensure that the necessary action is taken to achieve or maintain legal and regulatory compliance.

c) Organizations should seek out the most appropriate means for accessing the information, including the media supporting the information (e.g. paper, optical storage disk, intranet, internet). The organization should also evaluate which requirements apply and where they apply, and who needs to receive which kind of information.

d) Other asset management requirements could, for example, include parent company requirements, guidance from regulatory bodies, guidance from industry and trade associations, manufacturer's requirements, or any other asset management related standards that the organization subscribes to or that are deemed necessary for the effective implementation of the asset management system.





### 4.4.9 Management of change

Where existing arrangements are revised, or new arrangements are introduced that could have an impact on asset management activities, the organization shall assess the associated risks before the arrangements are implemented. The new or revised arrangements to be considered shall include:

a) revised organizational structure, roles or responsibilities;

b) revised asset management policy, strategy, objectives or plans;

c) revised process(es) or procedure(s) for asset management activities;

d) the introduction of new assets, asset systems or technology;

e) the introduction of new contractors or suppliers.

The organization shall ensure that risks are managed in accordance with **4.4.7**.

The organization should ensure that risk assessments are performed for any significant changes to elements of the asset management system. This does not necessitate additional risk management processes but ensures that there are existing arrangements in place which provide assurance that risk assessment is carried out when, for example, the following changes occur:

- revised organizational structure, roles or responsibilities;
- revised asset management policy, strategy, objectives or plans;
- revised process(es) and/or procedure(s) for the control activities;
- the introduction of new assets, asset systems or technology;
- the introduction of new contractors or suppliers.

Existing processes relating to the organizational structure, for example, should ensure that changes to that structure are risk assessed.

## 4.5 Implementation of asset management plan(s)

### 4.5.1 Life cycle activities

The organization shall establish, implement and maintain process(es) and/or procedure(s) for the implementation of its asset management plan(s) and control of activities across the whole life cycle, including:

a) creation, acquisition or enhancement of assets;

b) utilization of assets;

c) maintenance of assets;

d) decommissioning and/or disposal of assets.

The requirement for documentation to control these asset life cycle activities shall be in accordance with **4.4.5**.

The process(es) and/or procedure(s) for the implementation of the asset management plan(s) and for the control of life cycle activities shall:

i) be sufficient to ensure that operations and activities are carried out under specified conditions;

ii) be consistent with the asset management policy, asset management strategy and asset management objectives;

iii) ensure that costs, risks and asset system performance are controlled across the asset life cycle phases.

The organization shall ensure that the planned arrangements, functional policies, standards, process(es) and procedure(s), asset management enablers and resources are utilized for the efficient and cost effective implementation of the asset management plan(s).

The organization should establish and maintain arrangements to ensure the effective control of all activities required to fulfil the asset management policy, strategy, objectives and plans, the control of its asset-related risks, and the conformity to legal, statutory and other asset management requirements.

Fundamental to the principles of asset management set out in PAS 55-1 is the controlled delivery of the asset management plan(s) through the day-to-day activities of the organization. In practice this means that procedures and processes need to be in place, which set out roles and accountabilities for every asset management activity, and introduce the necessary governance and controls for managing unplanned events or variations to the plan.

#### *4.5.1.1 Implementing the asset management plan(s)*

Asset management plan(s) should address all of the life cycle phases and all asset types, although the structure and composition of those plans may be varied accordingly. The structure and composition of the plans, and the implementation of those plans, will also vary with organizational and industry requirements. The following guidance should be considered in light of each of the life cycle phases.

a) The asset management plan(s) should state who is responsible for the effective, efficient and compliant delivery of the plan(s). This responsibility includes ensuring necessary resources are available to deliver the plan(s) on time, within the allocated budget and that the delivery of the plan(s) conforms to all applicable legislative, and statutory requirements, policies, standards, process(es) and/or procedure(s) and any other requirements to which the organization may subscribe. Provision could be made in the plan(s) for the nominated individual to sign as a formal acceptance of this responsibility.

b) Deliverables, and procedures for managing variations in the delivery of the plan, should be agreed and understood by all parties, with appropriate governance in place. The overall responsibility for the monitoring and management of plan delivery should be unambiguously designated.

c) In-house delivery departments, supply chain partners and other outsourced suppliers should be incentivized consistently with the delivery of the plan, and the organization's key performance measures. Where practicable, common measures and targets should be shared between contributing parties.

d) Information systems should provide adequate information to enable the efficient and economic delivery of asset management plan(s), with arrangements in place to ensure that asset information, records and other relevant data is of the necessary quality and accessible in the appropriate format to those responsible for plan delivery.

e) Quality assurance processes should be aligned to the delivery of the plan, ensuring that all aspects of asset management activities conform to relevant standards, specifications and other requirements (including safety, legal and environmental requirements).

f) The delivery of the plan should include scheduling and management of resources and ensuring that sufficient materials, suitably qualified staff, tools,

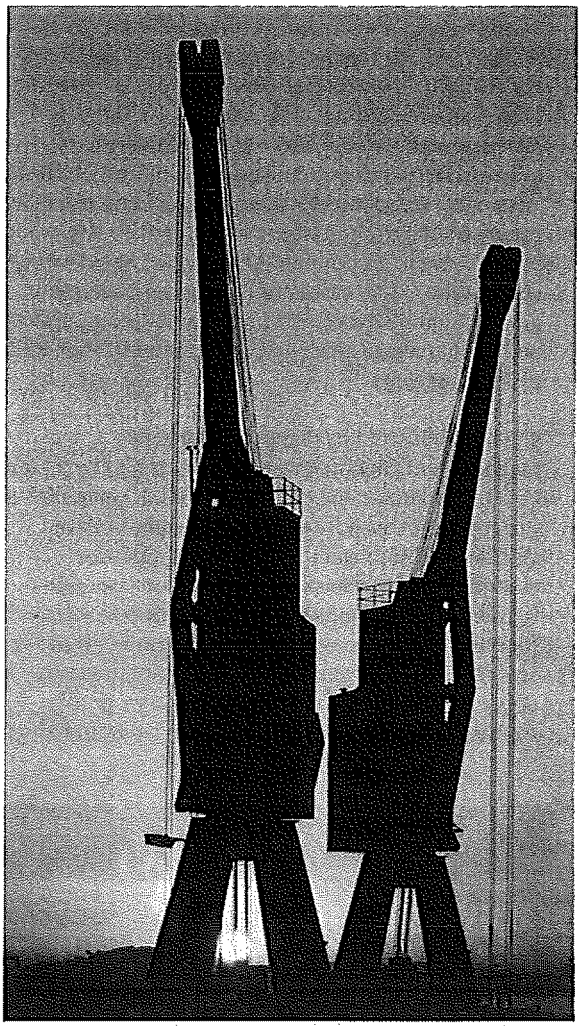
access equipment, etc. are available. Scheduling should be designed to optimize the use of resources, consistent with the efficient delivery of the plan, and include due consideration of logistics and contingencies for foreseeable unplanned work and overruns.

g) Plan delivery should align with constraints and wider business objectives. Specifically, plans and schedules should align with operational objectives, ensuring that work is prioritized, optimally bundled and carried out consistently with shutdown or other access constraints.

h) Progress monitoring of the plan should be ongoing, with regular exchange of information, including forward predictions of completion dates and performance outcomes, between parties responsible for each asset management activity. Mechanisms should be in place to review and realign plans during the delivery phase, enabling the re-prioritizing of work or allocation of resources (including consideration of acceleration options where appropriate) in order to optimize the plan delivery when encountering unanticipated events.

i) There should be clear escalation procedures to enable the management of variations in plan delivery to be agreed. This should include decision making criteria if additional funds or resources are needed to address exceptional circumstances which cannot be accommodated within normal delivery control mechanisms.

j) Plan delivery should incorporate the updating of asset information and records, and the recording of condition and actual expenditure against assets to enable continuous improvement.



*4.5.1.2 Operational control of asset management processes*

In addition to the delivery of the asset management plan(s), PAS 55-1 requires organizations to maintain and improve the processes that manage all phases of life of asset systems. This includes all life cycle activities listed in PAS 55-1, **4.5.1** (create/acquire, utilize, maintain, decommissioning/disposal of assets). These activities should be controlled in line with the requirements of the asset management strategy, and should have clear boundaries, effective interfaces and coordination with associated activities. Governance and accountabilities should be unambiguous, effective and should not present any barriers to effective and efficient delivery.

Organizations can have a number of asset management functional policies; examples are shown in **4.4.5 (i)**. Functional policies provide a framework for the control of specific asset management related activities (such as capital investment, operation, maintenance, materials management or transport logistics). They also provide the workforce with clarity for what is expected of them and the boundaries for any permissible variability. For example, the following policy would require the production of a set of maintenance strategies and plans but it would also prevent a manager from simply employing the manufacturer's recommendations for maintenance activities:

> *Maintenance strategies will be proactive and risk-based, taking due account of asset criticality and condition.*

However, when formulating functional policies, care should be taken not to conflict with other organizational or asset management policies, or restrict managers to the extent that they are unable to take appropriate action for the optimal life cycle management of the assets. For example, a capital investment or purchasing policy should not encourage "cheapest purchase cost" solutions unless there are pre-considered life cycle cost, risk and/or performance reasons for this to be appropriate. Similarly, functional policies and any derived strategies should be appropriate to the operational role, context and criticality, and the value of the assets to which they apply.

In addition to generic considerations and functional policies applicable in the control of asset management activities, there are specific considerations regarding each of the life cycle phases (see **4.5.1**).

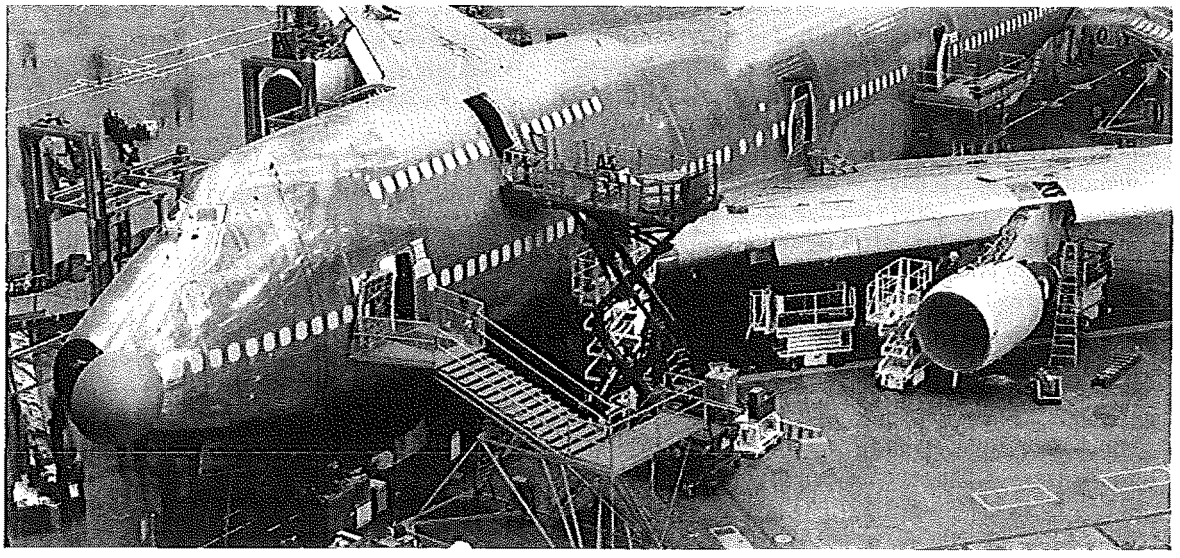
*4.5.1.3 Creation, acquisition or enhancement of assets*

Adding to, or enhancing assets, asset systems or the asset portfolio are critical, often high cost activities, with long-term consequences and uncertainties about their future utilization, performance, costs and risks. Procedures and operational controls for asset acquisition, creation or modification therefore need to match the planning and scheduling processes closely to ensure that required design criteria are met at optimal life cycle cost. Opportunities and options encountered during the acquisition, creation or enhancement of assets should be evaluated for whole life cost, performance and risk impact to determine if the asset management plan(s) should be changed to exploit the opportunities and/or mitigate the risks (see also **4.4.9**).

The management of major projects or construction programmes can take on many forms, with some organizations preferring strategies where contracted service providers have responsibility for design, engineering, procurement and construction ("buy and build"), or "buy, build and maintain" or even "buy, build, operate and maintain" (see also **4.4.2**). Control and alignment with the organizational strategic plan and asset management policy, strategy, objectives and performance standards should be considered in the choice of these options, ensuring that life cycle costs, long-term performance and the organizational strategic plan goals are not compromised.

Major projects or construction programmes are often managed by consortia of organizations working together, or by a number of independent contributing organizations supplying specialist services to the asset owner or manager. In such cases it remains critically important for the construction and procurement programme to be optimized (within known constraints) based on whole life cost and value, in line with the asset management policy, strategy and plan. There are legal, health, safety and environmental compliance requirements set down for construction, in addition to any specific asset management requirements. Practical implementation also requires good project management, with clear accountabilities, risk management, mechanisms for addressing nonconformities and change control (see Project Management Body of Knowledge Guide: 2004). The scheme of incentives and alignment of business drivers, including sharing of knowledge and long-term mutual commitment and management of interfaces are important mechanisms for improving the probability of success. Ultimately, however, the asset management organization has accountability for due diligence in appointing competent contractors and delivering investment value for money.

In the early life cycle stage (create/acquire assets) it is of particular importance to ensure that new assets meet quality assurance requirements and are handed over in good operational order to those responsible for future operation (utilization and maintenance) of the assets. This will include consideration of training and knowledge transfer and the provision of necessary design, operations, performance, reliability, maintainability and life cycle assumptions, guidance and data. Effective commissioning procedures, warranty conditions and provision of all records and asset data should normally be tied in to contractual requirements.



#### *4.5.1.4 Utilization of assets*

During the utilization of assets, consideration should be given to how operating criteria are defined, documented and communicated, as well as how they are controlled and monitored. Examples include the use of temporary speed restrictions in a railway network, the specification and monitoring of optimal temperature and pressure ranges in a chemical process, or the ambient lighting and temperature conditions for office buildings.

It is important that the operational parameters and controls are considered and managed in conjunction with maintenance arrangements (because of the potential impact of utilization upon asset degradation characteristics, failure risks and asset life cycles). For example, if the landing gear of an aircraft is maintained on a schedule linked to the numbers of landings, then variations in the operational flying regime need to be reflected into the maintenance programme so that relevant maintenance actions and resources can be suitably adjusted.

#### *4.5.1.5 Maintenance of assets*

Controls for maintenance of assets should be consistent with ensuring compliance with the asset management policy, asset management strategy and asset management objectives, and take account of asset operating parameters.

Consideration should be given to control mechanisms for ensuring that:

- staff are competent at the point of work;
- operating parameters are understood;
- appropriate records are kept.

Maintenance management systems are often used to coordinate maintenance activities. These systems may be based on simple scheduling tools, such as card/index systems, or more sophisticated work programming and schedule optimization tools. The organization should ensure that such systems are selected, implemented and utilized appropriately and effectively for the coordination and management of different types of maintenance activity (such as condition monitoring, inspection or predictive maintenance, planned preventive maintenance, function testing and corrective maintenance). Work procedures or instructions, standards and systems for supervision, checking or approvals (for example, "permit to work" systems) should be designed to ensure adequate control of quality, consistency and control of risk in the delivery of maintenance activities.

The control of maintenance activities should also reflect the criticality and urgency of the tasks (including timing criticality), the dynamic nature of condition-based work (where the scope of work depends upon the condition of the asset found during inspection), work bundling opportunities and resource constraints.

#### *4.5.1.6 Decommissioning and/or disposal of assets*

At decommissioning, the safe management and disposal of any redundant equipment should follow appropriate policies, including environmental management. From an asset management perspective, decommissioning should also include consideration of the long-term management of similar assets, and controlled retention if appropriate (for example, spare parts). It is also essential that records and asset information are correctly updated – it is good practice to write this into decommissioning procedures and include such obligations in contractual requirements. Decommissioning should ensure that equipment is removed as planned, and that remaining equipment is left in the required safe condition and that any relevant signs and notices are updated.

#### *4.5.1.7 Other operational controls*

The following list provides examples of the range of operational controls that might be employed by the organization in managing its assets.

a) *Control of imported risks*

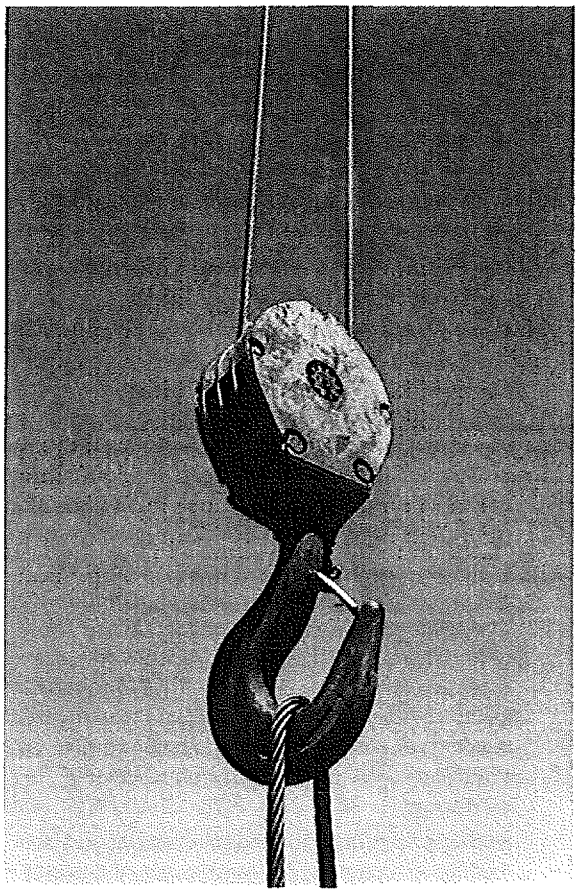
- assessment and approval of the design for new plant or equipment;
- procedures ensuring the availability of documentation for the safe handling, operation and maintenance of new machinery, equipment, materials or substances;
- evaluation, and periodic re-evaluation, of the competence of contractors;
- procedures for the review, approval and control of contracts.

b) *Controls on specific tasks*

- pre-determination and approval of working methods;
- pre-qualification of personnel for hazardous/critical tasks;
- permit-to-work systems, and procedures controlling the entry and exit of personnel to hazardous areas or those containing critical equipment;
- procedures for tactical planning, development, project management, scheduling and resource management.

c) *Controls on through-life management of plant and equipment*

- evaluation and approval procedures at the various asset life cycle stages, e.g. creation/acquisition, utilization, maintenance and decommissioning/disposal;
- procedures for the operation of plant and equipment;
- procedures for repair, maintenance and inspection activities;
- procedures for calibration and maintenance of tools and test equipments;
- procedures for the management of spares;
- isolation of equipment and segregation and control of access;
- maintenance, inspection and testing of protection systems and emergency equipment such as:
  - guarding and physical protection;
  - shutdown systems;
  - fire detection and suppression equipment;
  - essential monitoring devices.



**4.5.2 Tools, facilities and equipment**

The organization shall ensure that tools, facilities and equipment are maintained and, where appropriate, calibrated. The organization shall establish and maintain process(es) and procedure(s) to control these maintenance and calibration activities, where such tools, facilities and equipment are essential for:

a) the implementation of its asset management plan(s);

b) achieving the required function(s) and performance from its assets or asset systems;

c) the monitoring and measurement of performance and/or condition.

As part of the Plan-Do-Check-Act processes, a wide variety of parameters are defined during the development of policies, processes, standards and plans. Some of these require tools, facilities or measuring/test equipment to effect their implementation. It is essential that any tools, facilities or equipment that are required for the delivery and/or control of asset management activities are themselves identified and managed as assets, at a level of detail appropriate to their criticality.

Any monitoring equipment or instrumentation that is built into an asset may require periodic calibration or testing; this should be regarded as an intrinsic need of the asset itself, to be identified, planned and controlled appropriately.

It is important to consider how tools, facilities and equipment are identified and tracked through their usage and life cycles. It is also important to know where and when they have been applied; for example, if a piece of test equipment is found to be significantly out of tolerance, it may be important to be able to trace where and when it has been used so that re-testing can be carried out.

## 4.6 Performance assessment and improvement

### 4.6.1 Performance and condition monitoring

The organization shall establish, implement and maintain process(es) and/or procedure(s) to monitor and measure the performance of the asset management system and the performance and/or condition of assets and/or asset systems. The process(es) and/or procedure(s) shall provide for the consideration of:

a) reactive monitoring to identify past or existing nonconformities in the asset management system, and any asset-related deterioration, failures or incidents;

b) proactive monitoring to seek assurance that the asset management system and assets and/or asset systems are operating as intended. This shall include monitoring to ascertain that the asset management policy, strategy and objectives are met, the asset management plan(s) are implemented, and that the process(es), procedure(s) or other arrangements to control asset life cycle activities are effective;

c) leading performance indicators to provide warning of potential non-compliance with the performance requirements of the asset management system and/or the assets and/or asset systems;

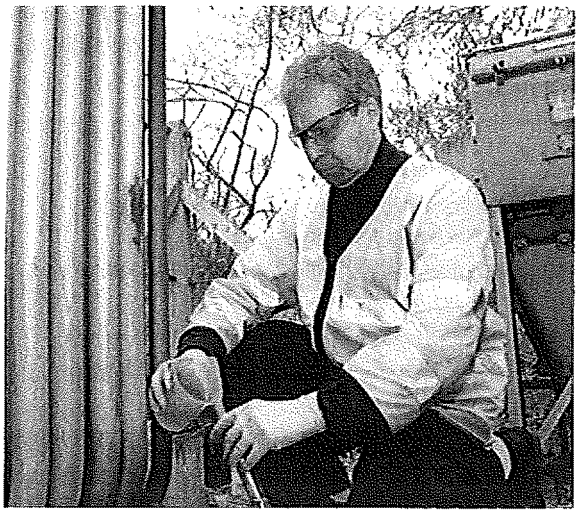
d) lagging performance indicators to enable detection of, and to provide data about, incidents and failures of the asset management system, and for incidents, failures or deficient performance of assets and/or asset systems;

e) both qualitative and quantitative measures, appropriate to the needs of the organization;

f) monitoring the overall effectiveness and efficiency of the asset management system;

g) recording of monitoring and measurement data and results to facilitate subsequent analysis of problem causes to assist in determining corrective or preventive actions and/or to facilitate continual improvement (in accordance with **4.6.5**).

When setting the frequency of condition or performance monitoring and the parameters for measurement the organization shall consider, at a minimum, the costs of monitoring, the risks of failure or nonconformity, and potential deterioration mechanisms and deterioration rates.



Organizations seeking to implement the requirements of PAS 55-1 on performance and condition monitoring, should consider the following recommendations and guidance.

a) The overall purpose of monitoring asset management performance is to evaluate the implementation of asset management objectives, the effectiveness of the arrangements for controlling risk and enable the identification of the need to restore or improve asset management performance.

b) PAS 55 identifies the requirement for both reactive monitoring and proactive monitoring.

c) Reactive monitoring comprises structured responses to an indication of a deficiency or failure of the asset management system, assets or asset systems. This indication could be the failure of an asset, or assets failing to perform as expected, or it could be evidence that the asset management system itself is deficient, for example, as a result of an observation from an external party, such as a regulatory agency.

d) Proactive monitoring comprises timely routine and periodic checks that plans and planned arrangements have been implemented, to determine the level of conformance with asset management system requirements and to seek evidence of problems with the asset management system that have not otherwise come to the attention of the organization via reactive monitoring.

***NOTE*** *Performance and condition measurement and monitoring focuses on the performance of the asset*

*management system (i.e. processes) and the performance and/or condition of the assets or asset systems on a day-to-day basis, whereas auditing is a process for reviewing and evaluating the effectiveness of the asset management system retrospectively (normally based on an annual plan). The two should not be confused.*

e) Proactive monitoring should be carried out to determine whether:

- the asset management system is being operated as intended, i.e. asset management objectives, targets and plans have been set and are achieved;
- the assets and/or asset systems are functioning as required, i.e. the output, reliability, availability, condition, etc. from an asset and/or asset system are as planned;
- asset management plans, operational control criteria and applicable legislation, regulatory, statutory, and other asset management requirements are being complied with.

An exclusive reliance on reactive monitoring could lead to complacency, with the organization's asset management system likely to lie dormant until problems occur.

Proactive monitoring of asset management performance in many cases (for example where routine checks are carried out) leads to immediate corrective action and the information about the findings might not be formally recorded. Where practicable, organizations should record the findings of such proactive monitoring (and actions resulting) and should always document the findings of reactive monitoring (and actions resulting).

f) PAS 55 also identifies the requirement for both leading and lagging performance indicators.

- Leading performance indicators provide data on compliance or non-compliance with the performance requirements of asset management plan(s) and compliance or non-compliance with the organization's asset management system generally. They provide warning signs of potential problems, either before they occur or before they become significant. Leading indicators should be applied, in particular, to activities or processes that could have the greatest potential beneficial influence on subsequent asset performance. Leading performance indicators should predict the prevalence of lagging indicators in the months and years ahead. Such indicators are useful in that they provide early evidence of success or failure, although their link with long-term performance might not be perfect.

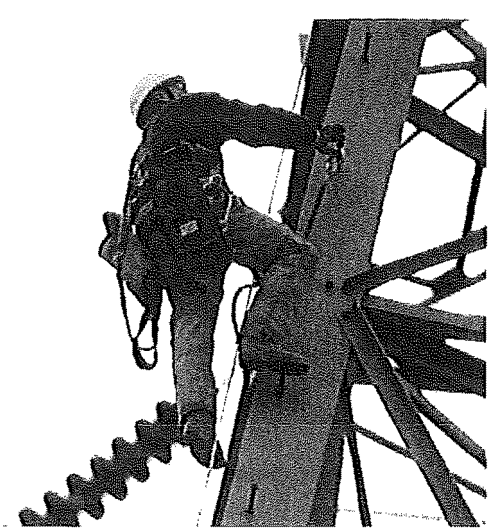
***NOTE*** *The data for leading indicators results mainly from proactive monitoring.*

- Lagging indicators provide data on performance results, such as the frequencies and severities of undesirable events; for example, incidents or failures of the asset management system, assets or asset systems. Lagging indicators are vital as they are the final check on the effectiveness of an asset management system. However, there are limitations relating to their use in the following circumstances:
  - monitoring the levels of risk for high impact, low probability events, such as those in the major hazard industries – there are too few failures to detect changes in the level of risk;
  - monitoring sustainability or long lead-time effects – problems are detected too late;
  - monitoring intangible or indirect effects such as reputation, employee morale, customer satisfaction – problems are detected too late.

***NOTE*** *The data for lagging indicators results mainly from reactive monitoring.*

- A combination of leading and lagging indicators should be used, since the two approaches are complementary; lagging indicators (for example asset failures) can reveal weaknesses in a system that is otherwise operating as intended, whereas leading indicators can detect non-conformances which can be corrected before adverse events occur.

g) The organization should identify key performance indicators (KPIs) as the principal indicators to be



used by top management to review the organization's asset management performance.

A large number of performance indicators might be required to monitor the implementation and effectiveness of the entire asset management system and the overall asset performance. However, this range of performance indicators should be aggregated into KPIs to enable senior staff to efficiently and effectively monitor the overall performance of the asset management system and assets. KPIs should comprise a small number of both leading and lagging performance indicators. It is essential that the KPIs selected are appropriate in terms of relevance and quantity and that senior staff have sufficient information but are not overloaded with data.

The top management of some organizations employ a "Balanced Scorecard". This comprises a relatively small number of KPIs, yet covers a broad range of organization objectives and performance criteria (note that a "balancing" mechanism is often missing – so that performance in one area may be at the expense of another). A corresponding "Asset Management Scorecard" should be considered to monitor the organization's overall asset management performance, provided that a clear understanding of individual goals is complemented by understanding of the trade-offs involved. An optimization method is needed to ensure that improvements in one KPI are not achieved at the disproportionate expense of another, e.g. an asset performance target is achieved but at excessive costs or risks.

h) The organization should identify parameters for its asset management performance across the whole organization. These should include, but not be limited to, parameters that determine whether:
   - asset management policy, strategy, objectives, targets and plans will be or are being achieved;
   - risk controls have been implemented and are effective;
   - the assets are achieving the performance and being maintained in the condition required of them and that lessons are being learnt from asset management system failures, including incidents, and potential nonconformities (near misses);
   - awareness, training, communication and consultation programmes for employees and interested parties are effective;
   - information that can be used to review and/or improve aspects of the asset management system is being produced and being used.

i) Organizations should base their performance measurement on a well-formulated combination of objective, subjective, quantitative and qualitative data types:
   - **objective data:** data which is detached from an assessor's personal judgement;
   - **subjective data:** data which could have been influenced by those doing the measuring. These measures can be very useful but need to be treated with care;
   - **quantitative data:** data which describes numbers and recorded on a scale. Where possible, it is desirable to quantify performance measures so that comparisons can be made over time. However, such data might give an unjustified impression of precision;
   - **qualitative data:** data which describes conditions or situations that cannot be recorded numerically. While qualitative data is very important it might be difficult to relate to other performance measures.

j) The use of a combination of these various data types will provide a better overall assessment of the asset management system and asset performance than reliance on only one type of measure. In general, however, objective and quantitative measures should be the preferred choice if critical business processes or assets are being monitored.

k) Attention should be given to the level of competence required of those responsible for planning, collecting and analysing data from performance measures.

l) The scope, level of scrutiny, frequency of measurement and condition or performance alarm levels (at which point remedial action is initiated) should be optimized and risk-based. These criteria may be adjusted over time as information accumulates, the stability of the system is established, and confidence in the asset management system increases. The minimum frequency of inspection for some assets may be determined by legislation.

m) Evidence of internal/external benchmarking exercises and acting on the results obtained can be helpful in demonstrating that the organization is committed to performance measurement and improvement.

n) It may be appropriate periodically to commission the independent gathering of physical condition data for the assets to verify the accuracy of asset data records and to validate the results from any predictive tools used to estimate asset condition.

   ***NOTE*** *The word "independent" here does not necessarily mean external to the organization.*

**4.6.2 Investigation of asset-related failures, incidents and nonconformities**

The organization shall establish, implement and maintain process(es) and/or procedure(s) for the handling and investigation of failures, incidents and nonconformities associated with assets, asset systems and the asset management system. These process(es) and/or procedure(s) shall define responsibility and authority for:

a) taking action to mitigate consequences arising from a failure, incident or nonconformity;

b) investigating failures, incidents and nonconformities to determine their root cause(s);

c) evaluating the need for preventive action(s) to avoid failures, incidents and nonconformities occurring;

d) communicating, as appropriate to relevant stakeholders, the results of investigations and identified corrective action(s) and/or preventive action(s).

Investigations shall be performed within a timescale commensurate with the actual and/or potential consequences of the failure, incident or nonconformity.

***4.6.2.1 General***

Organizations should have effective procedures for reporting, evaluating and investigating incidents and non-conformances. The prime purpose of the procedure(s) is to prevent further occurrence or escalation of such situations by identifying and dealing with the root cause(s). Furthermore, the procedures should enable the detection, analysis and elimination of potential causes of non-conformities.

The organization should prepare procedures to ensure that incidents and non-conformances are investigated, and corrective and/or preventive actions initiated. Progress in the completion of corrective and preventive actions should be monitored, and the effectiveness of such actions reviewed.

Immediate action to be taken upon observation of non-conformances, incidents or cases of imminent risk should be known to all parties and should be reflective of the risk associated with the non-conformance or incident.

Root cause analysis should be used to investigate critical asset-related failures or incidents, repetitive failures or incidents and significant non-conformances (including near misses).

Where solutions or improvements related to critical assets are identified, systematic identification, selection and cost/risk/performance evaluation of these solutions or improvements should be carried out.

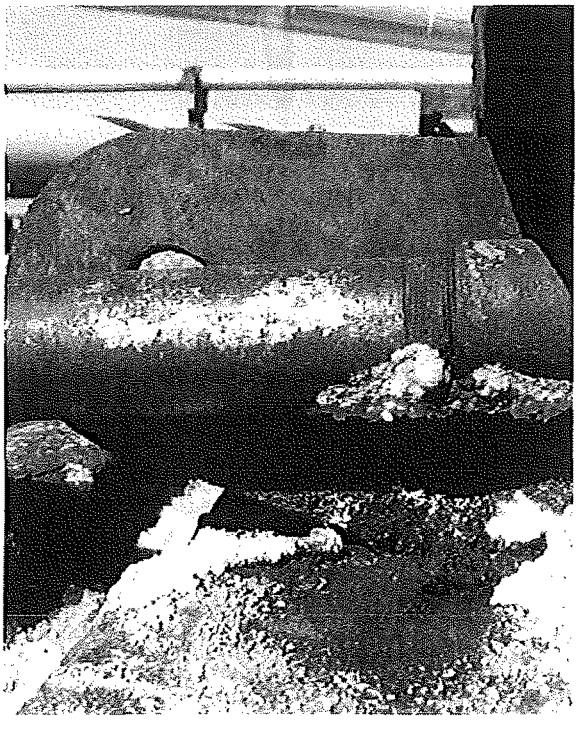
It might not be appropriate to investigate each and every non-critical asset failure and it therefore might be more efficient to classify such failures into categories of similar events, which are then subjected to a generic assessment and course of action that could facilitate trend analysis.

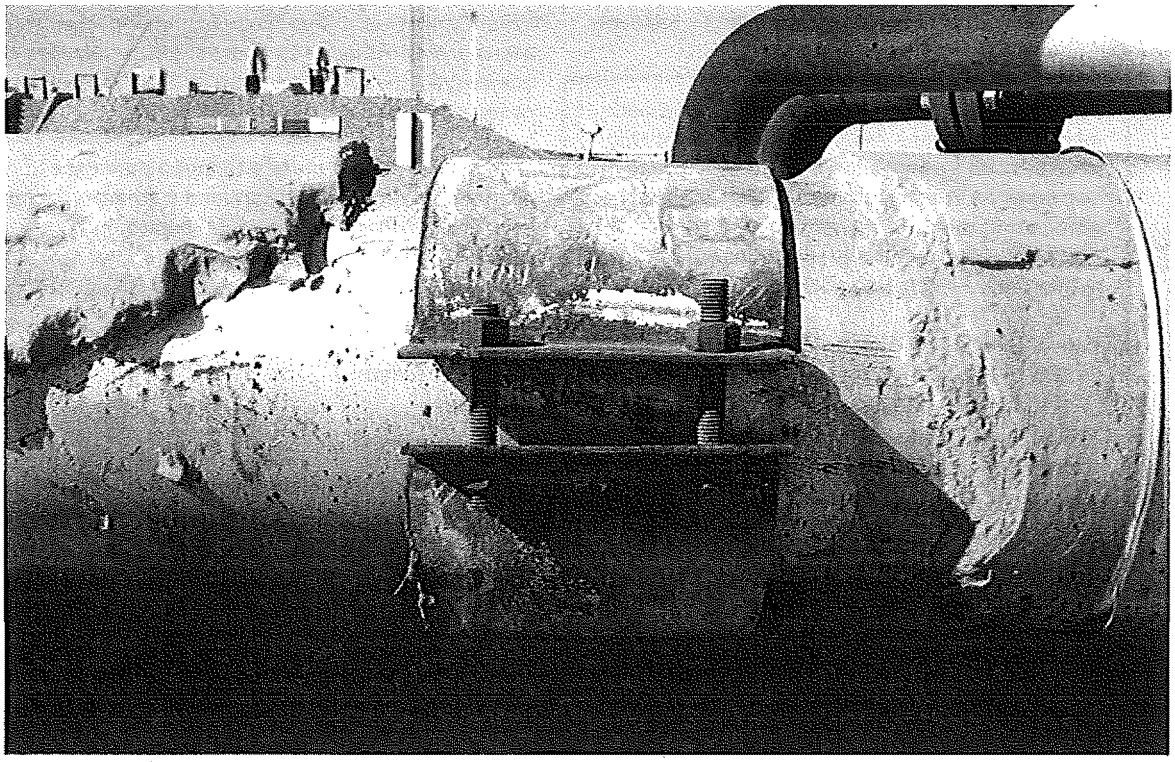
***4.6.2.2 Procedures***

***4.6.2.2.1 General***

Any procedures should:

- define the responsibilities and authorities of the individuals involved in implementing, reporting, investigating, follow-up and monitoring of corrective and preventive actions;
- require that all non-conformances, incidents, and cases of imminent risk are reported;
- clearly define the course of action to be taken following non-conformances identified in the asset management system;
- where an incident has legal or regulatory implications (for example health, safety or environmental) then the procedures should ensure compliance with any legal or regulatory requirements.





#### *4.6.2.2.2 Immediate action*

Immediate action to be taken upon observation of non-conformances, incidents or cases of imminent risk should be known to all parties. The procedures should:

- define the process for notification;
- where appropriate, include co-ordination with emergency plans and procedures;
- define the scale of investigative effort in relation to the potential or actual harm, e.g. include top management in the investigation of serious incidents.

#### *4.6.2.2.3 Recording*

Appropriate means should be used to record the factual information and the results of the immediate investigation and the subsequent detailed investigation. The organization should ensure that the procedures are followed for:

- recording the details of the non-conformance, incident or cases of imminent risk;
- defining where the records are to be stored, and responsibility for the storage.

#### *4.6.2.2.4 Investigation*

The procedures should define how the investigation process should be handled. The procedures should identify:

- the type of events to be investigated, e.g. service interruption incidents above a defined threshold (such as duration and number of customers affected);
- whether the involvement of external agencies and authorities is required;
- the purpose of investigations;
- who is to investigate, the authority of the investigators, required qualifications (including line management when appropriate);
- the process for establishing the root cause of the non-conformance;
- arrangements for witness interviews;
- practical issues such as availability of cameras and storage of evidence;
- investigation reporting arrangements including statutory reporting requirements.

Investigatory personnel should begin their preliminary analysis of the facts while further information is collected. Data collection and analysis should continue until an adequate and sufficiently comprehensive explanation is obtained.

### 4.6.3 Evaluation of compliance

> The organization shall establish, implement and maintain process(es) and/or procedure(s) for evaluation of its compliance with applicable legal and other regulatory or absolute requirements, and shall determine the frequency of such evaluations.
>
> The organization shall keep records of the results of these evaluations.

An organization should establish, implement and maintain a procedure for periodically evaluating its compliance with the legal or other requirements that are applicable to its asset management, as part of its commitment to compliance.

Evaluation of the organization's compliance should be performed by competent persons either from within the organization and/or using external resources.

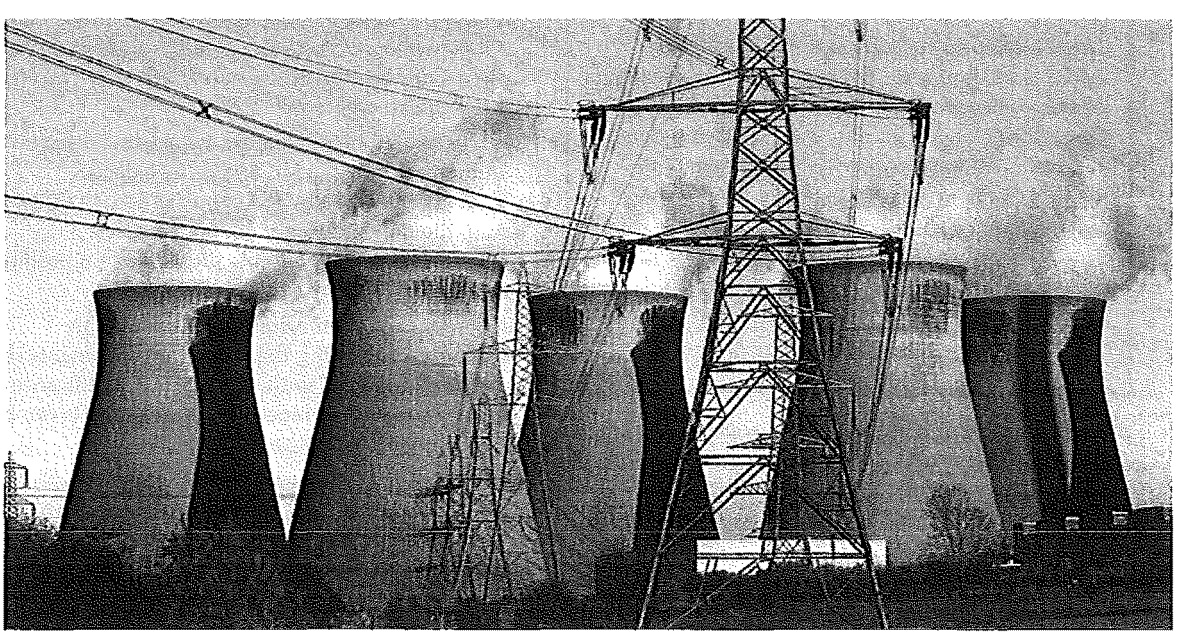
A variety of inputs can be used to assess compliance, including:

- audits;
- the results of regulatory inspections;
- analysis of legal and other requirements;
- reviews of documents and /or records of incidents and risk assessments;
- interviews;
- facility, equipment and area inspections;
- project or work reviews;
- analysis of test results from monitoring and testing;
- facility tours and/or direct observations.

The organization's processes for the evaluation of compliance can depend on its nature (size, structure and complexity). A compliance evaluation can encompass multiple legal requirements or a single requirement. The frequency of evaluations can be affected by factors such as past compliance performance or specific legal requirements. The organization can choose to evaluate compliance with individual requirements at different times or at different frequencies, or as appropriate. A compliance evaluation programme can be integrated with other assessment activities. These can include management system audits, environmental audits or quality assurance checks.

Similarly, an organization should periodically evaluate its compliance with other requirements to which it subscribes (see **4.4.8**). An organization can choose to establish a separate process for conducting such evaluations or it may choose to combine these evaluations with its evaluations of compliance with legal requirements (see above) and/or its management review process (see **4.7**) or other evaluation processes.

The results of the periodic evaluations of compliance with legal or other requirements should be recorded.



### 4.6.4 Audit

The organization shall ensure that audits of the asset management system are conducted to:

a) determine whether the asset management system:

i) conforms to planned arrangements for asset management, including the requirements of **Clause 4**;

ii) has been implemented and is maintained;

iii) is effective in meeting the organization's asset management policy, asset management strategy and asset management objectives.

b) provide information to management.

Audit programme(s) for elements of the asset management system shall be planned, established, implemented and maintained by the organization, based on the results of risk assessments of the organization's activities, and the results of previous audits.

Audit process(es) and/or procedure(s) shall be established, implemented and maintained to address:

1) the responsibilities, competencies and requirements for planning and conducting audits, reporting results and retaining associated records;

2) the determination of audit criteria, scope and methods that are commensurate with the business significance and risks being managed.

The selection of auditors and the conduct of audits shall ensure objectivity and the impartiality of the audit process. Audits shall be conducted by personnel independent of those having direct responsibility for the activity being examined.

***NOTE 1*** *The term "independent" here does not necessarily mean external to the organization.*

***NOTE 2*** *It is recommended that the selection of auditors considers their level of understanding of good practice in asset management and familiarity with the requirements of* ***Clause 4*** *of this PAS.*

Auditing is a process whereby organizations can review and continuously evaluate the effectiveness of their asset management system. Organizations seeking to implement the requirements of PAS 55-1 on audit, should consider the following recommendations and guidance.

a) An audit should:

- confirm whether the system meets the requirements of PAS 55-1;
- establish the degree of compliance with the documented asset management procedures;
- assess whether or not the system is effective in meeting the asset management policy, strategy and objectives of the organization;
- identify any corrective actions required to achieve compliance with the requirements.

b) The audit should include assessing and determining the viability and suitability of the asset management policy, strategy, objectives and plans, particularly in relation to critical assets and asset systems, to ensure that they are:

- consistent with each other;
- adequate;
- achievable.

Establishing whether they are adequate and achievable also requires assessment of the organization's:

- asset management related assumptions;
- process(es) and/or procedure(s), methods, tools and techniques;
- availability/allocation of funds;
- availability/allocation of resources (including competencies);
- availability/allocation of time (including timing interdependencies).

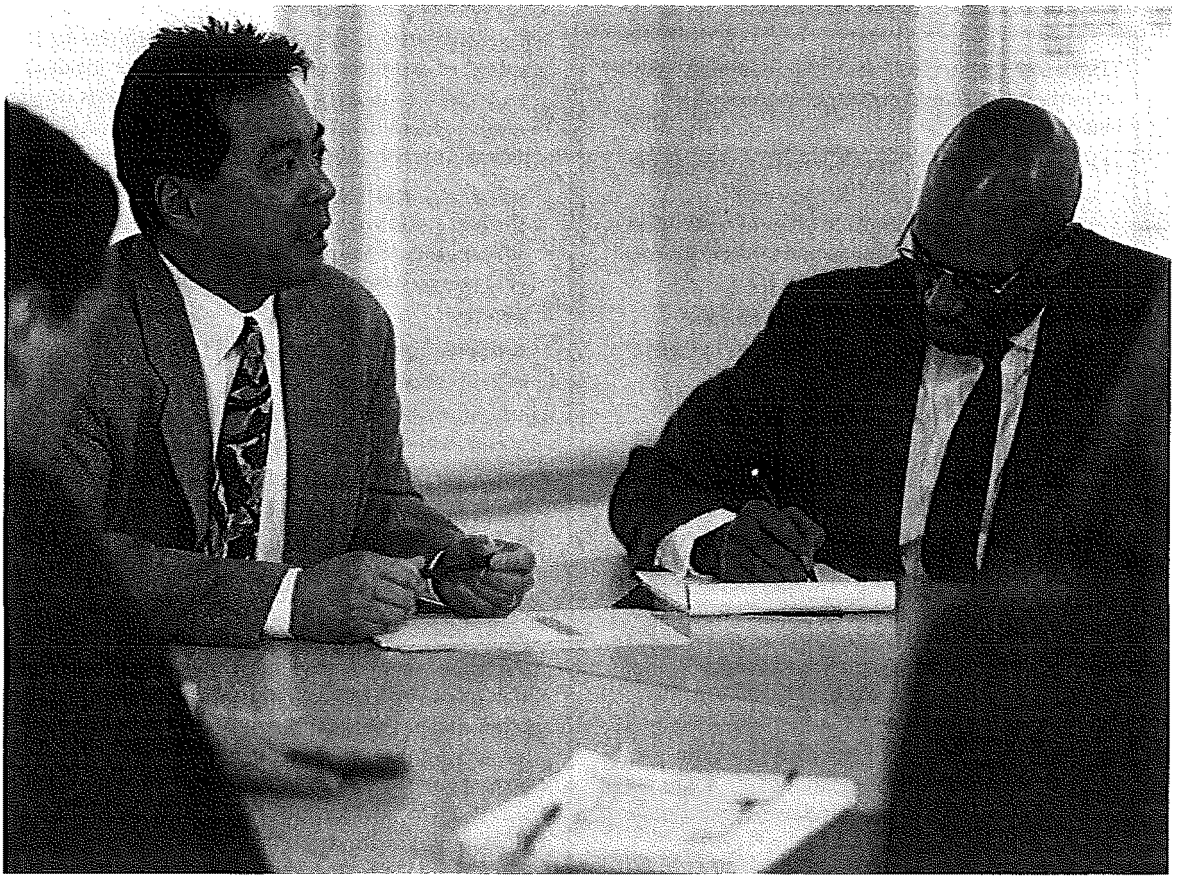
c) The results of the asset management system audits should be recorded and reported to management in a timely manner. A review of the results should be carried out by management and effective corrective action taken where necessary.

d) Audits should be carried out by personnel from within the organization and/or by external personnel selected by the organization. In either case, the personnel conducting the asset management system audits should be in a position to do so impartially and objectively.

e) Asset management system audits should be conducted according to planned arrangements that are commensurate with the business significance and risks being managed. Additional audits can be performed as circumstances require.

***NOTE*** *The general principles and methodology described in BS EN ISO 19011 are appropriate for asset management system auditing.*

f) The audit should provide comprehensive coverage of the whole asset management system. This may



require a rolling programme of audits across the organization, and may require auditors with different expertise to contribute to the different elements. It may be appropriate to use a combination of audits to get the necessary depth and coverage, taking either:

- a "horizontal slice": for example, an audit of asset management plan(s) across the organization to verify that the plans conform to the relevant requirements in PAS 55-1; or
- a "vertical slice": for example, the arrangements to manage a specific asset over its life cycle, or a specific asset-related risk, are audited in terms of the asset management policy and asset management strategy, asset management plan(s), the enabling and control processes (including risk management), implementation of asset management plan(s), performance monitoring and management review.

g) The audit process should establish the effectiveness of the system in managing the assets in accordance with the organization's policy and objectives (validation audit) and also that the organization is following its own procedures (compliance audit). Where the asset management system is additionally required to conform to an external specification this should also be verified.

h) The audit process should also look for changes in business and asset operating context that renders stated procedures and processes invalid, thereby introducing risk.

i) The auditor should be aware that the existence of an asset management policy, strategy, objectives, targets and plans alone are no guarantee that they are (or will be) effective in the optimal management of the assets. Therefore, the auditor should seek further evidence to validate the effectiveness of the asset management system.

j) The audit process should also encourage auditors to identify opportunities for continual improvement. Active participation, understanding and support of the organization's employees are important in achieving this.

### 4.6.5 Improvement actions

#### *4.6.5.1 Corrective and preventive action*

The organization shall establish, implement and maintain process(es) and/or procedure(s) for instigating:

a) corrective action(s) for eliminating the causes of observed poor performance and nonconformities identified from investigations, evaluations of compliance and audits to avoid their recurrence;

b) preventive action(s) for eliminating the potential causes of nonconformities or poor performance.

Any corrective or preventive actions taken and their timings shall be commensurate with the risk(s) encountered.

Where a corrective or preventive action identifies new or changed risks, or the need for new or changed process(es), procedure(s) or other arrangements to control asset life cycle activities, the proposed actions shall be risk assessed prior to implementation (see **4.4.7**).

The organization shall keep records of the corrective and preventive actions (see **4.6.6**) taken and communicate these to relevant stakeholders.

The organization shall ensure that any necessary changes arising from corrective and/or preventive actions are made to the asset management system.

##### *4.6.5.1.1 Corrective action*

Corrective actions are actions taken to address the root cause(s) of identified non-conformances, or incidents, in order to prevent, or reduce the likelihood of recurrence. Aspects to be considered in establishing and maintaining corrective action procedures include:

- identification and implementation of corrective measures both for the short-term as well as long-term (this can also include the use of appropriate sources of information, such as advice from employees with asset management expertise);
- evaluation of any impact on risk identification, and assessment results (and any need to update risk identification, assessment and control report(s));
- initiation and implementation of corrective action;
- recording any required changes in procedures resulting from the corrective action or risk identification, assessment and control, and implementation of these changes.

##### *4.6.5.1.2 Preventive action*

Preventive actions are those taken to address the root cause(s) of potential non-conformances or incidents, as a proactive measure, before such incidents occur. Examples of elements to be considered in establishing and maintaining preventive action procedures include:

- use of appropriate sources of information, e.g. trends in asset performance indicating imminent risk of failure, failure rates across a population of assets, revised risk assessments, data on environmental changes;
- identification of any potential problems requiring preventive action;
- use of an appropriate methodology to select a suitable and sufficient preventive action;
- initiation and implementation of preventive action;
- recording of any changes in procedures resulting from the preventive action.

##### *4.6.5.1.3 Follow up*

Corrective or preventive action taken should be as permanent and effective as practicable. Checks should be made on the effectiveness of corrective/preventive action taken. Checks should also be made to ensure that any temporary containment measures have been removed.

Outstanding/overdue actions should be escalated as appropriate via management.

##### *4.6.5.1.4 Non-conformance, and incident analysis*

Identified causes of non-conformances and incidents should be classified and analysed on a regular basis. Frequency and severity ratings should be calculated in accordance with accepted industry practice for comparison purposes.

Valid conclusions should be drawn and corrective action taken. At least annually, this analysis should be circulated to top management and included in the management review (see **4.7**).

##### *4.6.5.1.5 Monitoring and communicating results*

The effectiveness of asset management investigations and reporting should be assessed. The assessment should be objective, and should yield a quantitative result if possible.

The organization, having learnt from the investigation, should:

- identify the root causes of deficiencies in the asset management system and general management of the organization, where applicable;

- communicate findings and recommendations to management and relevant interested parties (see 4.4.4);
- include relevant findings and recommendations from investigations in the continuing asset management review process;
- monitor the timely implementation of remedial controls, and their subsequent effectiveness over time;
- apply the lessons learnt from the investigation of non-conformances across the whole organization, focussing on the broad principles involved, rather than being restricted to specific action designed to avoid repetition of a precisely similar event in the same area of the organization;
- provide a standardized reporting system so as to efficiently analyse the amount and type of asset-related failures, incidents and non-conformances occurring and how effectively they are being dealt with.

#### 4.6.5.2 Continual improvement

The organization shall establish, implement and maintain process(es) and/or procedure(s) for identifying opportunities and assessing, prioritizing and implementing actions to achieve continual improvement in:

a) the optimal combination of costs, asset related risks and the performance and condition of assets and asset systems across the whole life cycle;

b) the performance of the asset management system.

The organization shall actively seek and acquire knowledge about new asset management-related technology and practices, including new tools and techniques, and these shall be evaluated to establish their potential benefit to the organization.

Opportunities to improve should be identified, assessed and implemented across the organization as appropriate, through a combination of monitoring and corrective actions for the assets and/or asset systems and/or the asset management system.

Continual improvement should be regarded as an iterative activity with the ultimate aim to be to deliver organizational objectives. It should not be interpreted as cyclic (e.g. annual) improvements in asset performance parameters just because they can be achieved.

Often organizations are not aware of new technology, tools or methods that have been proven to be of measurable benefit to other organizations. Active research is required to identify, investigate, trial and evaluate such opportunities. Examples of how organizations acquire such knowledge include:

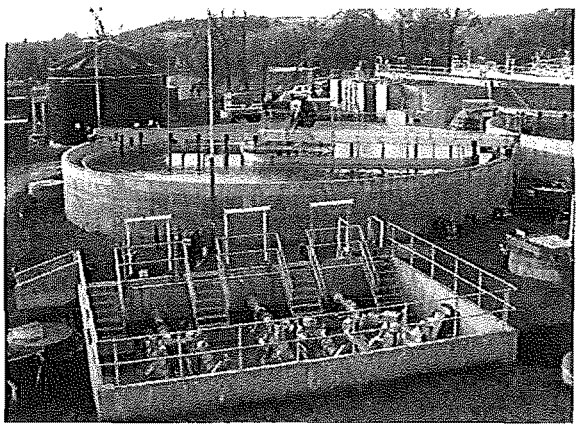
- employing specialist organizations and personnel;
- professional bodies and trade associations;
- conferences, forums, seminars, journals, publications and other media;
- benchmarking and cross-industry technology transfer;
- alliances, contractors and service providers;
- existing suppliers and alternative technology or service vendors;
- research and development activities, results of academic research;
- tracking competitors.

### 4.6.6 Records

The organization shall establish and maintain records as necessary to demonstrate conformance to the requirements of its asset management system and **Clause 4** of this PAS.

Records shall be legible, identifiable and traceable.

Records shall be maintained in accordance with the requirements of **4.4.6.**



Organizations seeking to implement the requirements of PAS 55-1 on records, should consider the following recommendations and guidance.

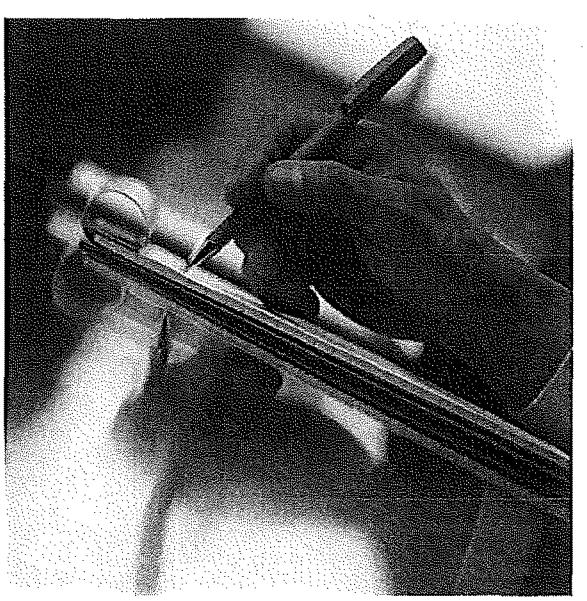
a) Keeping records and managing them effectively gives the organization a reliable source of information on the operation and results of the asset management system. Records should be kept to demonstrate that the asset management system operates effectively, and that processes have been carried out under prescribed conditions. Records that demonstrate the organization's conformance with the requirements of the asset management system should remain legible, readily identifiable, traceable and retrievable.

b) PAS 55 requires that records are kept:
   - for essential information generated whilst responding to and managing incidents and emergencies;
   - for training provided;
   - for maintenance, and where appropriate, calibration of specified tools, equipment and facilities;
   - for monitoring and measurement of the performance of the asset management system, and the performance and/or condition of assets and/or asset systems;
   - for evaluations of compliance with legal or other requirements;
   - on the results of audits;
   - on details of corrective and preventive actions;
   - for management review.

c) An organization should determine which records are required to manage its asset management activities effectively. In addition to those identified in b) above, asset management records could include:
   - asset management related complaints records, e.g. from customers, regulators, employees;
   - the results of identification of risks or risk assessments;
   - inspection, maintenance and calibration records;
   - pertinent contractor and supplier information;
   - incident and non-conformance reports/registers;
   - evidence of emergency preparedness and response, including the results of testing contingency plans.

d) Acceptable records can take many forms. For example, records of management review can include copies of meeting agenda items, lists of attendees, presentation materials or handouts, and management decisions recorded in a memo to file, reports, minutes or tracking system.

e) Asset management records should be controlled in the same way as other important asset management information.



## 4.7 Management review

Top management shall review at intervals that it determines appropriate the organization's asset management system to ensure its continuing suitability, adequacy and effectiveness. Reviews shall include assessing the need for changes to the asset management system, including asset management policy, asset management strategy and asset management objectives.

Input to management reviews shall include:

a) results of internal audits and evaluations of compliance with applicable legal requirements and with other requirements to which the organization subscribes;

b) the results of communication, participation and consultation with employees and other stakeholders (see **4.4.4**);

c) relevant communication(s) from external stakeholders, including complaints;

d) records or reports on the asset management performance of the organization;

e) the extent to which objectives have been met;

f) performance in addressing incident investigations, corrective actions and preventive actions;

g) follow-up actions from previous management reviews;

h) changing circumstances, including developments in legal and other requirements related to asset management and changes in technology.

The management review shall also cover aspects of the asset management system, if any, that are outsourced to a contracted service provider.

The outputs from management reviews, consistent with the organization's commitment to continual improvement, shall include decisions and actions for possible changes to:

1) asset management policy, strategy and objectives;

2) asset management performance requirements;

3) resources;

4) other elements of the asset management system.

Outputs from management reviews, which are relevant to the organizational strategic plan, shall be made available to top management for consideration in reviews of the organizational strategic plan.

Records of management reviews shall be retained and information relevant to specific employees, contracted service providers or other stakeholders made available for communication purposes (see **4.4.4**).

Organizations seeking to implement the requirements of PAS 55-1 on management review, should consider the following recommendations and guidance.

a) Top management should review the operation of the asset management system to assess whether it is being fully implemented and remains suitable for achieving the organization's stated asset management policy, strategy, objectives, targets and plans.

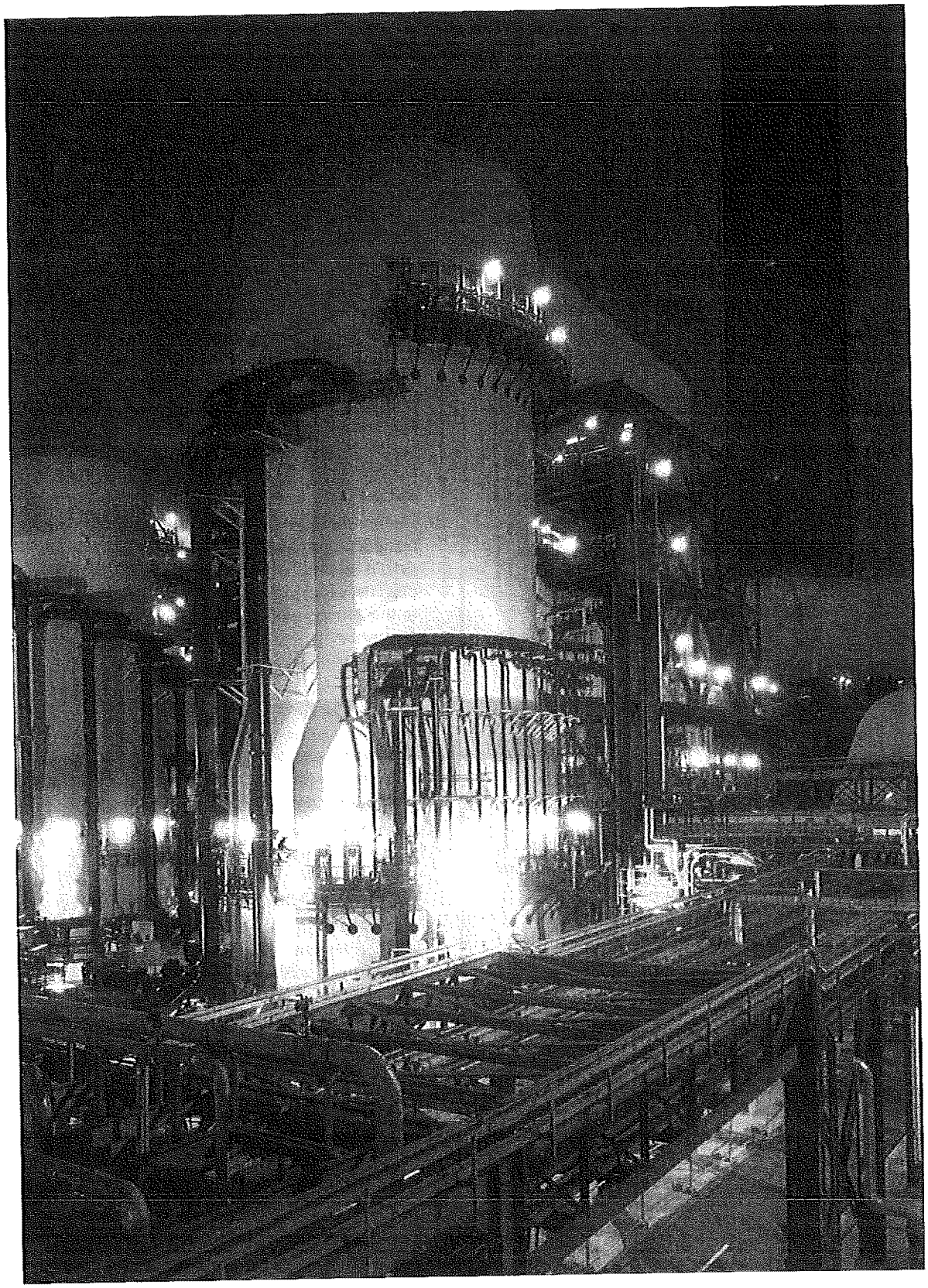
b) The review should also consider whether the asset management policy continues to be appropriate. It should establish new or updated asset management objectives for continual improvement, appropriate to the coming period, and consider whether changes are needed to any elements of the asset management system.

c) Reviews should be carried out by top management on a regular basis, e.g. annually. The review should focus on the overall performance of the asset management system and not on specific details, since these should be handled by the normal means within the asset management system.

d) It is essential that any deficiencies and/or opportunities for improvement identified as a result of the management review are addressed and the asset management system amended accordingly.

e) The results of the management review including any recommendations for changes to the asset management system should be communicated to appropriate stakeholders.

f) The results of the management review should be documented and will form part of the asset management system documentation (see **4.4.5**).



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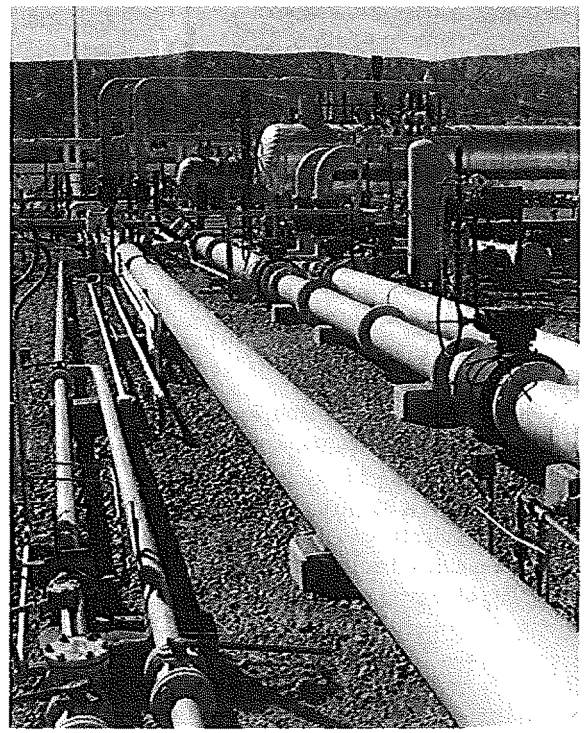

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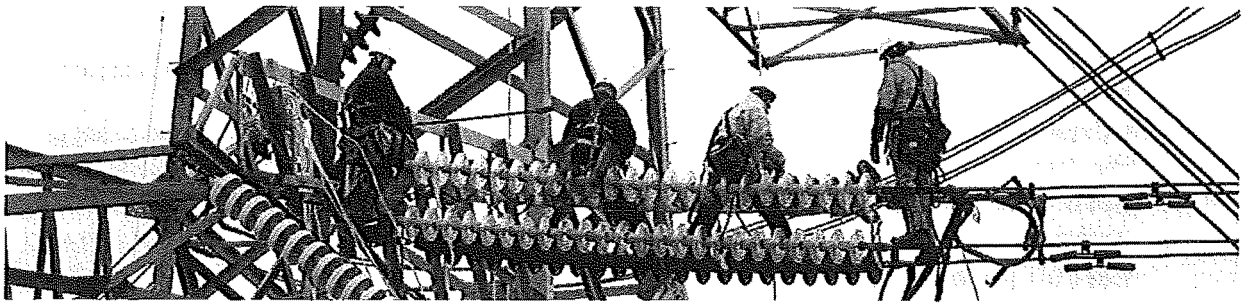

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